Towards Gravity-Gauge-Higgs Unification[1]

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Abstract

We discuss a possibility to solve the gauge hierarchy problem in the framework of Gravity-Gauge-Higgs Unification scenario. We have calculated 1-loop correction to the mass of the scalar field, which is originated from 55-component of the metric, in five dimensional gravity theory with the bulk scalar field compactified on S^1. It is shown that the quadratic divergences are canceled and the finite mass is generated by explicit diagrammatic calculations and the effective potential calculations.

One of the approaches to solve the gauge hierarchy problem is a Gauge-Higgs unification scenario. In this scenario, Higgs field is identified as extra dimensional components of the gauge field in higher dimensional gauge theory. In particular, it has been known that 1-loop correction to the Higgs mass becomes finite in five dimensional QED compactified on S^1 [1].

In this talk, motivated by the Gauge-Higgs unification scenario, we have discussed a possibility to solve the gauge hierarchy problem in the framework of the Gravity-Gauge-Higgs unification scenario in which Higgs is identified as extra dimensional components of the metric tensor field [2]. As a prototypical model, we take a five dimensional gravity theory coupled with a bulk scalar field, compactified on S^1. 1-loop correction to Higgs mass is explicitly calculated in a diagrammatical way. We clarified that quadratic divergences are canceled only when all KK modes are summed up in the internal loop in order to maintain the general coordinate transformation invariance. Furthermore, we have obtained a finite mass which is generated by the non-local effects. This result corresponds to that the finite mass is obtained in five dimensional QED compactified on S^1 only when all KK modes are summed up in the internal loop in order to maintain the local gauge

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symmetry. What is nontrivial in this calculation is that the finite mass cannot be obtained unless the vacuum bubble diagram and the tadpole diagram which seems not to contribute to mass correction are taken into account. For simplicity, we have calculated 1-loop correction to Higgs mass via the bulk scalar field. Quantum corrections from the fields with other spin, such as the graviton, the vector field and the fermion, are easily obtained by multiplying the number of the degrees of freedom of physical polarization to the result from the bulk scalar field.

We have also calculated the effective potential for the Higgs field and obtained the finite mass in a systematic way. We have checked that the both results completely agree.

In Gauge-Higgs unification scenario, we can understand that the finite mass for Higgs field is generated by nontrivial appearance of Wilson loop. In Gravity-Gauge-Higgs unification scenario, however, it is not clear that a similar understanding can be applied since the naive correspondence to Wilson loop is not the line integral of the five-five component of the metric but the line integral of the Christoffel symbols, whose physical meaning has not been clarified so far.

Realistic model construction in this scenario is left for future investigations.

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References

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